

ASTEROID PHOTOMETRY AND LIGHTCURVE ANALYSIS FOR EIGHT ASTEROIDS

Milagros Colazo

Instituto de Astronomía Teórica y Experimental
(IATE-CONICET) ARGENTINA

Facultad de Matemática, Astronomía y Física
Universidad Nacional de Córdoba, ARGENTINA

Grupo de Observadores de Rotaciones de Asteroides (GORA)
ARGENTINA

<https://aoacm.com.ar/gora/index.php>
milirita.colazovinovo@gmail.com

César Fornari, Giuseppe Ciana, Damián Scotta, Mario Morales,
Raúl Melia, Aldo Wilberger, Néstor Suárez, Bruno Monteleone,
Alberto García, Marcos Anzola, Francisco Santos,
Aldo Mottino, Carlos Colazo

Grupo de Observadores de Rotaciones de Asteroides (GORA),
ARGENTINA

Observatorio Astronómico Giordano Bruno (MPC G05)
Piconcillo (Córdoba-ESPAÑA)

Observatorio Astronómico El Gato Gris (MPC I19) – Tanti
(Córdoba-ARGENTINA)

Observatorio de Sencelles (MPC K14) - Sencelles
(Mallorca-Islas Baleares-ESPAÑA)

Osservatorio Astronomico “La Macchina del Tempo” (MPC M24)
Ardore Marina (Reggio Calabria-ITALIA)

Observatorio Los Cabezones (MPC X12) - Santa Rosa
(La Pampa-ARGENTINA)

Observatorio Galileo Galilei (MPC X31) - Oro Verde
(Entre Ríos-ARGENTINA)

Observatorio Antares (MPC X39) – Pilar
(Buenos Aires-ARGENTINA)

Observatorio Río Cofio (MPC Z03) - Robledo de Chavela
(Madrid- ESPAÑA)

Specola "Giuseppe Pustorino 3" (GORA GC3) - Palizzi Marina
(Reggio Calabria-ITALIA)

Observatorio de Damián Scotta 1 (GORA ODS) - San Carlos
Centro (Santa Fe-ARGENTINA)

Observatorio de Damián Scotta 2 (GORA OD2) - San Carlos
Centro (Santa Fe-ARGENTINA)

Observatorio Astronómico Vuelta por el Universo (GORA OMA)
Córdoba (Córdoba-ARGENTINA)

Observatorio de Raúl Melia Carlos Paz (GORA RMG)
Carlos Paz (Córdoba-ARGENTINA)

(Received: 2023 March 20)

Synodic rotation periods and amplitudes are reported for
244 Sita, 329 Svea, 421 Zahringia, 904 Rockefelleria,
2479 Sodankyla, 4373 Crespo, (143947) 2003 YQ117,
and 2015 RN35.

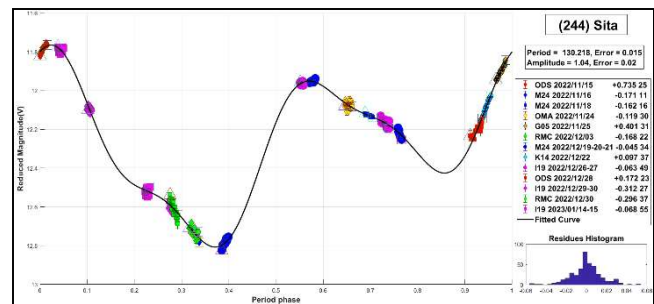
The periods and amplitudes of asteroid lightcurves presented here are the product of collaborative work by GORA (Grupo de Observadores de Rotaciones de Asteroides). In all the studies, we have applied relative photometry assigning V magnitudes to the calibration stars.

Image acquisition was performed without filters and with exposure times of a few minutes. All images used were corrected using dark frames and, in some cases, bias and flat-fields were also used. Photometry measurements were performed using *FotoDif* software. We employed *Períodos* software (Mazzone, 2012) for analysis.

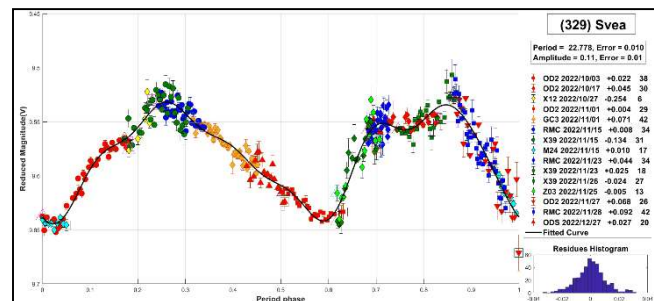
Below, we present the results for each asteroid under study. The lightcurve figures contain the following information: the estimated period and period error and the estimated amplitude and amplitude error. In the reference boxes, the columns represent, respectively, the marker, observatory MPC code, or - failing that - the GORA internal code, session date, session offset, and several data points.

Targets were selected based on the following criteria: 1) those asteroids with magnitudes accessible to the equipment of all participants, 2) those with favorable observation conditions from Argentina or Spain and Italy, i.e., with negative or positive declinations δ , respectively, and 3) objects with few periods reported in the literature and/or with Asteroid Lightcurve Database (LCDB; Warner et al., 2009) quality codes $U < 3$.

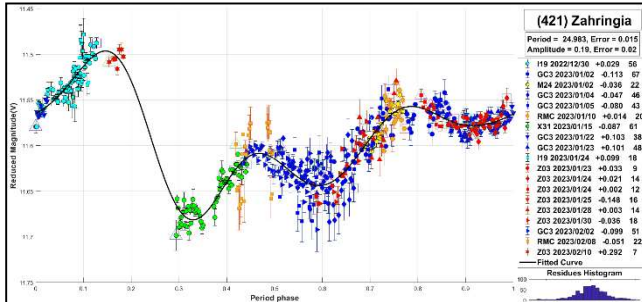
244 Sita was discovered in 1844 by J. Palisa. The most recent period published in the literature is $P = 129.06 \pm 0.02$ h with $A = 0.80 \pm 0.05$ mag (Vander Haagen, 2010). In this work, we provide similar results and propose $P = 130.218 \pm 0.015$ h and $A = 1.04 \pm 0.02$ mag.



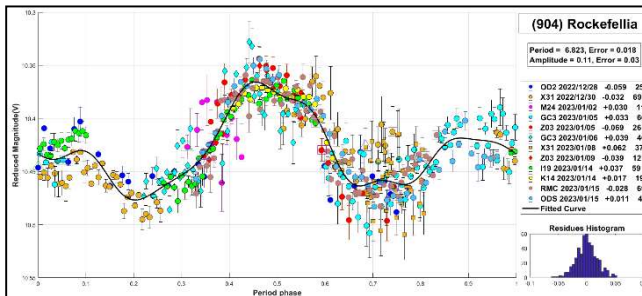
329 Svea is a C-type asteroid discovered in 1892 by M. Wolf. Several periods have been reported for this asteroid: $P = 15$ h (Weidenschilling et al., 1990), $P = 15.201 \pm 0.005$ h (Pray, 2006), $P = 22.6 \pm 0.01$ h (Menke et al., 2008), and $P = 22.778 \pm 0.006$ h (Marciniak et al., 2015). We have determined a period of 22.778 ± 0.010 h with $A = 0.11 \pm 0.01$ mag. This is consistent with the one proposed by Marciniak et al.



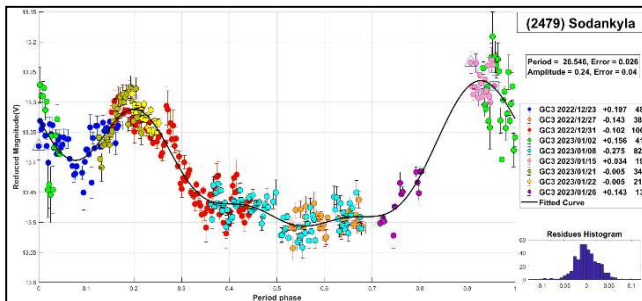
421 Zahringia is an S-type asteroid discovered in 1896 by M. Wolf. Several periods were previously measured for this asteroid: $P = 15.5 \text{ h} \pm 0.1 \text{ h}$ (Robinson, 2002), $P = 17.49 \pm 0.02 \text{ h}$ (Behrend, 2005web), $P = 6.42 \pm 0.01 \text{ h}$ (Warner, 2010), and $P = 25.4891 \pm 0.0376 \text{ h}$ (Waszczak et al., 2015). The results we obtained, $P = 24.983 \pm 0.015 \text{ h}$ with $A = 0.19 \pm 0.02 \text{ mag}$, are consistent with the longer period proposed by Waszczak et al.



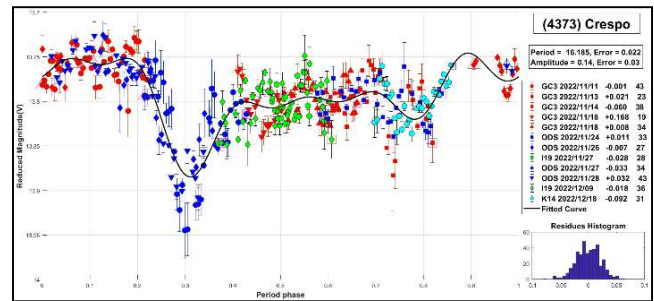
904 Rockefelleria was discovered in 1918 by M. Wolf. We found in the literature three rather different periods for this object: $P = 4.93 \text{ h}$ (CALL, 2011web), $P = 5.82 \pm 0.01 \text{ h}$ (Fauvaud and Fauvaud, 2013), and $P = 12.72 \pm 0.05 \text{ h}$ (Behrend, 2014web). Our analysis suggests a period that is consistent with the one proposed by Fauvaud and Fauvaud, i.e., $P = 6.823 \pm 0.018 \text{ h}$ and $A = 0.11 \pm 0.03 \text{ mag}$.



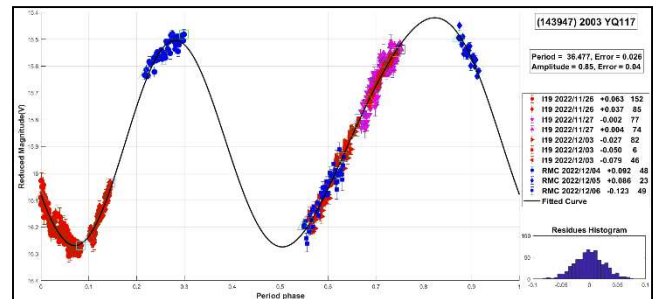
2479 Sodankyla was discovered in 1942 by Y. Vaisala. We couldn't find published periods in the literature for the asteroid. In this work, we propose a long-term period of $P = 26.546 \pm 0.026 \text{ h}$ with $A = 0.24 \pm 0.04 \text{ mag}$.



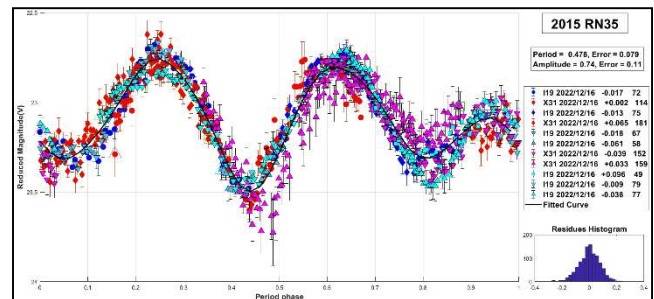
4373 Crespo was discovered in 1985 by E. Bowell. Interestingly, we couldn't find a reported period for this object in the literature. According to a thorough analysis of our observations, we propose a period of $P = 16.185 \pm 0.022 \text{ h}$ and $A = 0.14 \pm 0.03 \text{ mag}$.



(143947) 2003 YQ117 was discovered in 2003 by NEAT. It is a poorly studied object. Here we propose a tentative period of $P = 36.477 \pm 0.026 \text{ h}$ with $A = 0.85 \pm 0.04 \text{ mag}$.



2015 RN35. This hazardous asteroid was discovered in 2015 by Pan-STARRS. A great number of probable encounters of asteroid 2015 RN35 with the Earth have been predicted (Petrov et al., 2018; Sokolov et al., 2020). We couldn't find a reported period for this object in the literature. In this paper, we present full lightcurve coverage with observations made by overlapping different nights and telescopes, thus giving confidence to our result. We measured a period of $0.478 \pm 0.008 \text{ h}$ with $A = 0.74 \pm 0.11 \text{ mag}$.



Acknowledgements

We want to thank Julio Castellano as we use his *FotoDif* program for preliminary analyses, Fernando Mazzone for his *Periodos* program, used in final analyses, and Matias Martini for his *CalculadorMDE v0.2* used for generating ephemerides used in the planning stage of the observations. This research has made use of the Small Bodies Data Ferret (<http://sbn.psi.edu/ferret/>), supported by the NASA Planetary System. This research has made use of data and/or services provided by the International Astronomical Union's Minor Planet Center.

Number	Name	20yy/ mm/dd- yy/ mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
244	Sita	22/11/15-23/01/15	*5.6, 24.7	62	-2	130.218	0.015	1.04	0.02	MB-I
329	Svea	22/10/03-22/12/27	2.0, 22.8	10	-7	22.778	0.010	0.11	0.01	416
421	Zahringia	22/12/30-23/02/11	*15.0, 9.1	125	-10	24.983	0.015	0.19	0.02	MB-I
904	Rockefellia	22/12/28-23/01/15	9.5, 14.2	82	-18	6.823	0.018	0.11	0.03	MB-O
2479	Sodankyla	22/12/23-23/01/26	7.4, 23.6	82	3	26.546	0.026	0.24	0.04	MB-I
4373	Crespo	22/11/11-22/12/18	*5.5, 20.3	52	-7	16.185	0.022	0.14	0.03	MB-I
143947	2003 YQ117	22/11/26-22/12/06	67.5, 50.2	70	-40	36.477	0.026	0.85	0.04	NEA
	2015 RN35	22/12/16-22/12/16	44.1, 38.9	83	-20	0.478	0.079	0.74	0.11	NEA

Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extremum during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009). 416: 329 Svea, MB-I: main-belt inner, MB-O: main-belt outer.

MPC	Observatory	Telescope	Camera
G05	Obs.Astr.Giordano Bruno	SCT (D=203mm; f=6.3)	CCD Atik 420 m
I19	Obs.Astr.El Gato Gris	SCT (D=355mm; f=10.6)	CCD SBIG STF-8300M
K14	Obs.Astr.de Sencelles	Newtonian (D=250mm; f=4.0)	CCD SBIG ST-7XME
M24	Oss.Astr.La Macchina del Tempo	RCT (D250mm; f=8.0)	CMOS ZWO ASI 1600MM
X12	Obs.Astr.Los Cabezones	Newtonian (D=200mm; f=5.0)	CMOS QHY 174M
X31	Obs.Astr.Galileo Galilei	RCT ap (D=405mm; f=8.0)	CCD SBIG STF-8300M
X39	Obs.Astr.Antares	Newtonian (D=250mm; f=4.72)	CCD QHY9 Mono
Z03	Obs.Astr.Río Cofio	SCT (D=254mm; f=6.3)	CCD SBIG ST-8XME
GC3	Specola Giuseppe Pustorino 3	RCT (D=400mm; f=5.7)	CCD Atik 383L+Mono
ODS	Obs.Astr.de Damián Scotta 1	Newtonian (D=300mm; f=4.0)	CMOS QHY 174M
OD2	Obs.Astr.de Damián Scotta 2	Newtonian (D=250mm; f=4.0)	CCD SBIG STF-8300M
OMA	Obs.Astr.Vuelta por el Universo	Newtonian (D=150mm; f=5.0)	CMOS POA Neptune-M
RMC	Obs.Astr.de Raúl Melia Carlos Paz	Newtonian (D=254mm; f=4.7)	CMOS QHY 174M

Table II. List of observatories and equipment.

References

- Behrend, R. (2005web, 2014web). Observatoire de Geneve website. <https://obswww.unige.ch/~behrend/>
- Collaborative Asteroid Lightcurve Link (CALL; 2011) http://www.minorplanetobserver.com/DATA/submissions_results.htm
- Fauvaud, S.; Fauvaud, M. (2013). "Photometry of Minor Planets. I. Rotation Periods from Lightcurve Analysis for Seven Main-belt Asteroids." *Minor Planet Bulletin* **40**(4), 224-229.
- Harris, A.W.; Young, J.W.; Scaltriti, F.; Zappala, V. (1984). "Lightcurves and phase relations of the asteroids 82 Alkmene and 444 Gyptis." *Icarus* **57**, 251-258.
- Marciniak, A.; Pilcher, F.; Oszkiewicz, D.; Santana-Ros, T.; Urakawa, S. and 19 colleagues (2015). "Against the biases in spins and shapes of asteroids." *Planetary and Space Science* **118**, 256-266.
- Mazzone, F.D. (2012). Períodos software, version 1.0. <http://www.astrosurf.com/salvador/Programas.html>
- Menke, J.; Cooney, W.; Gross, J.; Terrell, D.; Higgins, D. (2008). "Asteroid Lightcurve Analysis at Menke Observatory." *Minor Planet Bulletin* **35**, 155-160.
- Petrov, N.A.; Vasil'ev, A.A.; Kuteeva, G.A.; Sokolov, L.L. (2018). "On the Trajectories of Asteroid Encounters with the Earth for 2015 RN35 and Apophis." *Solar System Research* **52**, 326-337.
- Pray, D.P. (2006). "Lightcurve analysis of asteroids 326, 329, 426, 619, 1829, 1967, 2453, 10518 and 42267." *Minor Planet Bulletin* **33**, 4-5.
- Robinson, L.E. (2002). "Photometry of Five Difficult Asteroids: 309 Fraternitas, 366 Vincentina 421 Zahringia, 578 Hapelia, 959 Anne." *Minor Planet Bulletin* **29**, 30-31.
- Sokolov, L.L.; Balyaev, I.A.; Kuteeva, G.A.; Petrov, N.A.; Eskin, B.B. (2020). "Possible Collisions and Approaches of Some Dangerous Asteroids with the Earth." *Solar System Research* **54**, 541-549.
- Vander Haagen, G.A. (2010). "Lightcurve and HG Parameters for Slow Rotator 244 Sita." *Minor Planet Bulletin* **37**, 44-45.
- Warner, B.D.; Harris, A.W.; Pravec, P. (2009). "The asteroid lightcurve database." *Icarus* **202**, 134-146.
- Warner, B.D. (2010). "Upon Further Review: I. An Examination of Previous Lightcurve Analysis from the Palmer Divide Observatory." *Minor Planet Bulletin* **37**, 127-130.

Waszczak, A.; Chang, C.-K.; Ofek, E.O.; Laher, R.; Masci, F.; Levitan, D.; Surace, J.; Cheng, Y.-C.; Ip, W.-H.; Kinoshita, D.; Helou, G.; Prince, T.A.; Kulkarni, S. (2015). “Asteroid light curves from the Palomar Transient Factory survey: rotation periods and phase functions from sparse photometry.” *Astronomical Journal* **150**, 75.

Weidenschilling, S.J.; Chapman, C.R.; Davis, D.R.; Greenberg, R.; Levy, D.H.; Binzel, R.P.; Vail, S.M.; Magee, M.; Spaute, D. (1990). “Photometric geodesy of main-belt asteroids: III. Additional lightcurves.” *Icarus* **86**, 402-447.

**ROTATION PERIOD DETERMINATION
FOR ASTEROID 2023 DZ2**

Nick Sioulas
NOAK Observatory (L02)
Stavraki Ioannina, Greece
nsioulas@hotmail.com

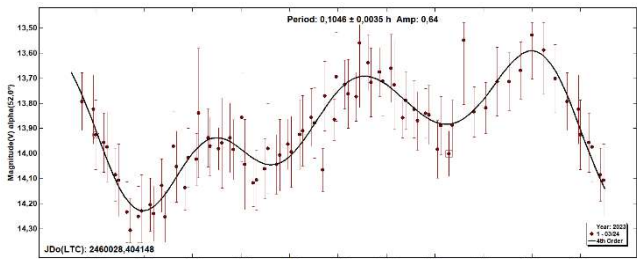
(Received: 2023 April 12)

Photometry of near-Earth asteroid 2023 DZ2 were conducted from the NOAK Observatory, located in Greece, to determine its synodic rotation period. The results are: $P = 0.1046 \pm 0.0035$ h, $A = 0.64$ mag.

All observations were performed at the NOAK Observatory, Ioannina Greece (MPC-International Astronomical Union code L02), using a 0.25m Newtonian Skywatcher optical tube operating at f/4.7. The optical tube is mounted on an NEQ6 Skywatcher robotic mount and equipped with ATIK 460exm CCD camera. It is a high Quantum Efficiency CCD. No filters used for better signal-to-noise. Exposure time for all the images was 5 seconds. The camera was binned at 2×2. The image scale after 2×2 binning was 1.57 arcsec/pixel and the field of view 35.9'×28.7'. In these fields, the asteroid and five comparison stars were measured for differential photometry.

All images were reduced in the standard manner using nightly flatfield files as well as dark-current and bias images. Photometric measurements and lightcurve analysis were performed using *MPO Canopus* (version 10.8.1.1; Warner, 2019). The *Cartes Du Ciel* was used as the planetarium software with the most recent ephemerides downloaded from MinorPlanetCenter and Artemis Capture was used for image capture.

2023 DZ2 was discovered by the Romanian-Spanish team Para-SOL (MPC 950). It is a near-Earth asteroid with a semi-major axis of 2.155AU, eccentricity 0.539, inclination 0.081deg, and an orbital period of 3.16 years. Its absolute magnitude is $H = 24.235$ (JPL, 2023). The period analysis shows a solution for the rotational period of $P = 0.1046 \pm 0.0035$ h with an amplitude $A = 0.64 \pm 0.03$ mag.



References

Harris, A.W., Young, J.W., Scaltriti, F., Zappala, V. (1984). “Lightcurves and phase relations of the asteroids 82 Alkmene and 444 Gyptis.” *Icarus* **57**, 251-258.

JPL (2023). Small Body Database Browser.
<https://ssd.jpl.nasa.gov>

Warner, B.D.; Harris, A.W.; Pravec, P. (2009). “The Asteroid Lightcurve Database.” *Icarus* **202**, 134-146. Updated 2019 Aug.
<http://www.minorplanet.info/lightcurvedatabase.html>

Warner, B.D. (2019). MPO Software, *MPO Canopus* v10.8.1.1. Bdw Publishing. <http://minorplanetobserver.com>

Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2023	DZ2	2023 03/26	92.8	232.4	-0.7	0.1046	0.004	0.64	0.03	Apollo

Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).